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DETERMINANTS OF CONTRACTOR PRICING STRATEGY

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DETERMINANTS OF CONTRACTOR PRICING STRATEGY

Abstract

This paper investigates pricing strategies used by major defense contractors. Two pricing strategies are identified and discussed: penetration, which calls for a relatively low initial price followed by little reduction in price over time, and skimming, which calls for a relatively high initial price coupled with greater reduction in price over time. It is argued that contractor pricing strategy will depend on features of the defense program under consideration and features of the economic environment prior to production on the program. An analysis was conducted using data from a sample of major weapons system programs in the aerospace industry. Findings indicate that factors related to the funding for a program, expected program length, defense spending and industry economic conditions influence contractor choice of pricing strategy.

DETERMINANTS OF CONTRACTOR PRICING STRATEGY

The acquisition of major weapon systems is time consuming, complex and expensive. During the acquisitions process, particularly during contract negotiation, both the Department of Defense and defense contracting firms pursue various strategies to achieve their, perhaps conflicting, objectives. One element of a contractor's strategy is his pricing strategy: the pattern of prices charged for units procured over time. Do unit prices decline as more units are procured or do unit prices remain fairly stable? We felt that understanding what factors influence contractor pricing strategy might be of value to contracting officers and program managers involved in the acquisitions process. This article argues that pricing strategy is influenced by both features of the program under consideration and features of the larger environment in which acquisition occurs. Evidence on what factors do effect pricing strategy is presented in the context of an analysis of strategies used by defense contractors within the aerospace industry.

Two Pricing Strategies

There are numerous ways to describe or categorize pricing strategies in general, but firms introducing new products or technology typically use one of two common product pricing approaches: penetration or skimming.[1] Discussed by many authors, the two strategies are widely understood and used by business practitioners. The objectives of the two strategies

differ. The skimming strategy calls for high initial prices followed by lower prices at later stages. The objective of the skimming strategy is to achieve the maximum profit in the short run by charging the highest price that the market will bear. Thus one advantage of skimming is a more rapid return on investment.

In contrast, the penetration strategy calls for a low initial price with little or no price reduction over time. The objective of the penetration strategy is to gain entry and establish a position in a market through a low initial price. Once the market has been captured, the firm can take advantage of either price increases or cost reductions to earn additional profits. The firm's established market position dampens the incentives of competitors to enter the market.

Pricing Strategy and Risk

Each of the two strategies can be described in terms of the relationship between two variables: the price of the first unit sold and the rate of price reduction over time. Skimmers exhibit a high first unit price and a steep price reduction curve, while penetrators exhibit a low first unit price and a flat price reduction curve. Neither strategy is inherently more profitable and both are observed in practice. The two strategies do however differ in the timing of profits (short-term versus long-term) and consequently in riskiness.

With a high initial price, skimming maximizes short-term

returns and provides a more rapid recovery of funds to finance the costs of product introduction and future expansion. By front-ending profit, skimming reduces the risk associated with uncertainty in the product's market. Skimming allows for greater flexibility; it is typically easier to introduce a product with a high price and then reduce the price than it is to introduce at a low price and increase price later to cover unexpected costs or exploit product popularity.[2] Skimming emphasizes short run profits and consequently reduces the risks associated with predicting future demand and future costs.

The penetration strategy sacrifices short run profits in an attempt to capture the market and generate profits over the long run. Penetration generally requires a greater commitment of the firm's resources, both because its long run orientation may require greater investment in productive capacity and because the required investment may not be adequately financed out of the relatively lower initial profits. "Attempting to take a sizeable (market) share through lower price is risky and often requires a heavy and long commitment of financial resources. Since the stakes and risks are high, the potential rewards must be substantial".[3] "High rewards are possible with this strategy but only if economies of scale occur as predicted. Therefore, it is often a high risk strategy as well, since the potential exists for disastrous losses if costs fail to decline as rapidly as expected. Production problems or unrealized sales volumes can also undermine this strategy".[4] Penetration appears to be the

more risky strategy.

Pricing Strategy in the Defense Market

Clearly defense acquisitions, particularly for major weapon systems, is specialized in nature. Both the products and market are not typical of products and markets in general. Major weapon systems are large dollar items which may represent a substantial segment of a manufacturer's business. Pricing strategy for such items is likely to be an important strategic decision. Major weapons systems incorporate significant innovation with state-of-the-art hardware and substantial uncertainty in development. But products involving significant innovation offer the possibility of "learning" over time and provide the greatest leeway in choosing a pricing strategy.[5] The market for defense systems is also unusual, with a single (monopsonistic) buyer and usually only a few (oligopolistic) sellers.

Readers familiar with defense contracting may question the ability of manufacturers to exercise a pricing strategy. Prices are determined primarily by competitive bids. A bid is accepted and a contract for a specified number of units is negotiated prior to production. Prices are specified in the contract and are based on costs incurred ("cost plus") using some agreed upon formula. Furthermore, cost estimates and their source must be disclosed at the time of contract negotiation, so some agreement on the validity of cost estimates is established up front. Hence, prices may seem to be a direct function of costs incurred,

with little leeway allowed for contractor pricing discretion. However, discretion enters through the determination of "cost."

In spite of regulation by the Cost Accounting Standards Board, which governs the accounting for costs on government contracts, substantial flexibility exists within allowable cost accounting procedures. The allowable procedures permit flexibility both in assigning cost to units produced and in assigning costs across different periods. Accounting procedures that permit the recognition of costs earlier or later provide a contractor with the flexibility to "cost justify" different pricing strategies.[6] Earlier recognition of costs is associated with a higher first unit price and a steeper price reduction curve. Delaying cost recognition permits a lower first unit price but results in a flatter price reduction curve.

For example CASB standard #409 permits contractors to use either straight line or accelerated depreciation methods to account for the cost of capital assets. Accelerated depreciation assigns greater cost to earlier periods (and units produced) and less to later periods. Standards for dealing with the treatment of materials (#411), acquisition cost of some assets (#404), home office expenses (#403), administrative expenses (#410), engineering costs (#420), service center costs (#418) and cost of money (#414, #417) also allow contractors to choose among different acceptable procedures or approaches in determining "cost." Flexibility is inherent in accounting.

Evidence from a study of major aerospace weapon systems

conducted by Greer[7] substantiates a strong relationship between accounting methods used by contractors and contractor pricing strategies. In short, while prices may be tied to costs incurred in the defense contracting market, firms have an ability to either skim or penetrate via the application of accounting methods. (No dishonesty is implied here. Contractors can legitimately select from among various acceptable procedures. They are simply required to use the same procedures in accounting for actual costs as were used in determining initial estimates of cost.)

If the acquisition of a particular defense system by the government occurred at a single point in time under a single unchangeable contract covering all units of a weapons system to be procured, the ability of a manufacturer to influence unit price through the measurement of cost would be of little importance; shifting costs from earlier units produce to later units (or vice versa) would have little impact on the total costs and price for the complete output produced. But features of the acquisitions environment preclude the use of a single, unchangeable contract covering all units to be manufactured during a weapons system acquisition program.

First, due to the complex nature and state-of-the-art technology involved in major weapon systems, contracts are frequently updated or revised to accommodate design and production changes. Revision of an individual contract provides the manufacturer the opportunity to "renegotiate" price and

profit. Second, because of the nature of the federal budget process, funding for units procured under a weapons system program is reviewed and approved on an annual basis. Consequently, system acquisition typically occurs in several stages under several different contracts. This letting of new contracts also provides the manufacturer the opportunity to renegotiate.

A potential contractor on a new weapons system has two alternatives. The firm can submit a high bid (e.g., skim by setting a high price for initial units produced), which tends to insure profitability and the recovery of invested funds in the short run but has the disadvantage that it increases the probability that a competitor will secure the contract. Or a firm can submit a low bid in an attempt to penetrate or "buy-in" to the initial contract to capture the market (sometimes at an initial loss) and presume that subsequent contract revision or renegotiation or future contracts will result in satisfactory profits in the long run.

The penetration strategy would appear to be more risky. The complexity, innovation, and high performance requirements associated with major weapon systems mean that their capability and reliability cannot always be assessed in advance. This creates uncertainties with respect to product acceptance and the future demand for additional units by the Department of Defense. Furthermore, the constantly changing economic and political environment creates uncertainties with respect to the willingness

of congress or the executive branch to budget for additional units. This results in uncertainties with respect to program curtailment or termination. Technical, political and economic consideration also effect the readiness of the Department of Defense to revise or renegotiate existing contracts.

Observation of a low initial price indicates a willingness by a contractor to commit resources to a program with the possibility of only relatively low short term profits (or even a loss). A low initial price signals a willingness to "bet" on the future and accept the risks of program curtailment or termination, the uncertainties involved in trying to increase price if contracts are revised, the uncertainties associated with future procurement contracts, and the accompanying uncertainties associated with long run profit realization.

It might be argued that skimming is risky because a skimmer has a greater "risk" of losing the contract. However this would be an inappropriate use of the term. Risk implies uncertainty, not probability. It is true that a skimming strategy increases the "probability" of losing a contract. But what a skimming strategy really signals is an unwillingness to place a "bet" on the uncertain future, an unwillingness to play the "game" unless success is assured through the locking in of profits in the short run by setting price high initially. A reluctance to play unless success is assured is consistent with risk averse behavior and fully consistent with penetration being a more risky strategy.

Neither strategy is inherently more profitable, although

they may differ in the timing of the realization of profits. When would a contractor adopt one strategy instead of the other? When would a contractor have an incentive to buy-in with a relatively lower initial price and accept the greater risks associated with the penetration strategy? In the next section we outline several factors that we felt had the potential for influencing contractor pricing strategy.

Factors Influencing Pricing Strategy

We thought that two broad concerns should influence contractor pricing strategy: The nature of the specific program under consideration and the nature of the political or economic environment existing at the time of contract negotiation on the program.[8] Several variables are listed below. Each is an attempt to reflect some feature of the program or some feature of the environment. We have tried to suggest, for each variable, how it might influence a contractor's willingness to compete by reducing initial price and hence why it might be associated with pricing strategy.

Program Value. Obtaining a contract for a major new weapons system is a significant event for a firm. Jobs are created and future profits are expected. We felt that a contractor's willingness to compete on price for a new program would be related to the value of the program to the firm, and expected that a penetration strategy would be more likely with higher value programs. Program value was measured by total cost of the

program over its life.

Program Length. Obtaining a contract for a program that is expected to extend over several future years has distinct benefits for a firm. Facilities costs can be amortized over longer periods. Revenues can be expected to continue for several future periods. We felt that willingness to compete on initial price would be influenced by the number of years a program was expected to run and expected that a penetration strategy would be more likely with longer term programs.

Program Size. As argued above, contractors may be more willing to compete on price for programs of high value. However, another factor may come into play. If an individual program is small relative to the total operations of a firm, experiencing unexpected costs and losses on the program, while damaging, would not be critical. In contrast, if an individual program comprises a substantial portion of a firms total operations greater risk is incurred. Unfavorable performance on the contract could have significant implications for the performance of the firm as a whole. Consequently when a program is large relative to the total operations of the contractor, we expected that contractors would be less willing to accept a low initial price, and instead reduce risk by pursuing a skimming strategy. We measured program size relative to firm size by dividing the average yearly value of a program by the contractor's total sales.[9]

Defense Spending. What was the congressional and budgetary environment like at the time programs were being negotiated? Were

constraints being imposed on defense spending? Were non-defense programs favored? Was defense spending increasing? We felt that contractors would have less incentive to reduce initial price if the environment appeared to be favorable to defense spending, hence a skimming strategy would be expected. Two variables were used to reflect the defense spending environment:[10] (a) Defense spending as a proportion of total federal spending, which indicates the relative budget emphasis between defense and non-defense federal programs, and (b) the rate of growth in defense spending, which indicates changing commitment to defense programs over time.

Industry Conditions. To the extent that an individual firm's facilities are currently being employed, incentives to compete for defense work in general and for a specific new defence contract in particular may be lessened. Such firms may feel they are in a strong position to bargain for a higher initial price. More generally, when facilities within an industry are being fully employed there may be reduced incentive for all firms to compete for additional work and less concern that a particular competitor will offer a low price to secure a program. In short, pricing strategy may be associated with current utilization of productive capacity within an industry. We expected the penetration strategy to be more likely when capacity utilization is relatively low.[11] Two variables were used to reflect the industry environment: a) percent of industry capacity utilization, which indicates current industry

conditions, and b) the rate of growth or decline in capacity utilization, which indicates the trend in industry conditions.

General Economic Conditions. Perhaps economic conditions-growth or contraction - influence pricing strategy. If the economy is robust, demand for products should be relatively greater, opportunities for commercial projects may be more plentiful, and incentives to compete on initial price for a particular defense contract may be reduced. Consequently a skimming strategy may be followed. When economic contraction occurs, new defense programs may appear more appealing and the increased incentives to compete for such contracts may result in a penetration strategy. The rate of growth in Gross National Product (constant dollar) was used to reflect economic conditions.

Inflation. Inflation makes future dollars worth less than current dollars. If inflation is high firms may prefer to adopt a pricing strategy that leads to rapid returns on a new project. As indicated previously, neither skimming nor penetration is an inherently more profitable strategy, but skimming, with the higher initial prices, tends to lead to more rapid returns and earlier recovery of funds. Consequently we expected skimming to be associated with an environment characterized by relatively greater inflation.

Commitment to the Program. There is inevitably some uncertainty concerning the long run commitment of the government to individual weapon systems. Long run plans may be made, but

the federal budget is discussed and revised annually. Programs that are supported one year by an administration or congress may be cut in subsequent years as the administration, congress or political conditions change. To the extent that long run commitment to a particular weapon system is doubtful, contractors may have incentives to seek relatively higher initial prices to reduce future risks of program curtailment, i.e. to skim. If commitment to a program is not in question, contractors may be more willing to buy into a contract, having greater confidence that program curtailment will not threaten returns expected in future years. Commitment to a program is not readily measured, but funds allocated to a program, as reflected in annual obligational authority, may provide an indication of the governments willingness to commit to the program. "Early" allocation of funds may reflect a strong initial commitment. We divided the initial year obligational authority for a program by the total obligational authority over the life of the program, creating a measure reflecting the proportion of the project that was funded "up front". We expected this measure of early commitment to be associated with a penetration pricing strategy by contractors.

Acquisitions Environment. The environment in which military acquisitions occur has not remained static over the years. The phrase "Military - Industrial Complex" was unfamiliar before Eisenhower left the presidency, but awareness of the links between the DoD and the defense industry is now pervasive. A

somewhat symbiotic relationship between the DoD and the defense industry has developed. Many stories of cost overruns have been told. Scrutiny of the acquisitions process by congress and the pubic has increased in recent years. Calls for increased competition have been heard. Oversight, regulations and procedures governing acquisition have been revised and altered over the years. Have these changes had any consistent effect on pricing strategy? To the extent that increasing scrutiny of defense acquisitions have motivated contractors to compete for defense work by offering lower initial prices, one might expect that penetration strategies have increased in more recent years. If the DoD has become more dependant on individual contractors, if weapon system technology has become more complex and uncertain (creating the opportunity for contractors to demand subsequent price increases to cover unexpected costs), and if contractors have become more powerful and successful in asserting demands for price increases, then one might also expect increasing use of penetration strategies in more recent years. It is possible to document whether there has been a general trend toward more or less use of one pricing strategy or the other. A variable indicating the calender year in which programs were initially undertaken is included in the analysis to capture any general trend.

A summary of the variables are included in table 1. In the following sections we provide evidence that the anticipated relationships between many of these factors and contractor

TABLE 1

SUMMARY OF VARIABLES

VARIABLE NAME	ABREVIATION	MEASURE
Program value	PVALUE	Total cost of program over its full life
Program Length	PLENGTH	Number of years program ran
Program Size	PSIZE	Average yearly value of program divided by contractor size (sales)
Defense Spending	DEFSPND	Defense spending divided by total federal spending
Defense Spending Growth	DEFGRO	Rate of change in Defense spending
Capacity Utilization	CAPU	Percentage of Aerospace industry capacity utilization
Capacity Utilization Growth	CAPUGRO	Rate of growth or decline in industry capacity utilization
Economic Growth	ECONGRO	Rate of growth or decline of GNP
Inflation	INFLA	Inflation rate measured using the producer price index-industrial
Funding Obligated	FUNDS	Initial obligational authority for a program divided by total obligational authority
Calender Year	YEAR	Year of initial production on program
Follow-On Program	FOLLON	Whether or not a program was a new model of a previously produced system

pricing strategy tend to exist.

Slope of the Price Reduction Curve

As indicated before, the two strategies can be described in terms of the relationship between first unit price and the subsequent price reduction curve. Learning curves can be used to distinguish the two strategies. Learning curve theory describes the decline in per unit production costs a manufacturer experiences with increasing volume. A per unit reduction can be extended conceptually to the measure of price per unit. Thus learning curves can also be used to represent price reduction curves.

The learning curve function relates price with volume as follows:

$$P=AX^{B}$$

Where P is the average price per unit of producing X units and A is the price of the first unit. The slope of the learning curve, S, is related to B as follows:

$$B = \frac{\ln S}{\ln 2}$$

A slope of 1.00 implies a horizontal line - i.e. no price reduction. The lower the decimal value of the slope, the higher the price reduction rate. For example, .800 is a steeper price reduction rate than .900.

In this study, we used slopes of learning curves fit to

actual prices to reflect pricing strategy. Relatively high values for S (flat slope) are consistent with penetration, while lower values (steeper reduction) are consistent with skimming.

Because price reduction slopes are used to reflect pricing strategy, one additional variable was included in the analysis as a control. While pricing strategy should affect the slope of the price reduction curve on a given project, pricing strategy is not the only factor influencing the slope. When a project is the first production model of a weapon system, some learning and some reduction in unit price over time can be expected. When a project is a "follow-on" project - a new model of previously produced item - less learning and price reduction should occur. For example Lockheed produced both the P-3a and P-3b. One would likely expect a flatter price reduction curve (higher slope) for the follow on P-3b model. A variable (FOLLOW), coded 1 if the program was the first production model of a weapon system and 2 if a follow-on model, was included in the analysis to capture this probable effect on price reduction slopes.

Aerospace Weapons Programs

We investigated pricing strategy for major military aircraft and missile weapon systems acquired by DoD from 1953-1980. Data on prices, and specifically price reduction slopes calculated using learning curves (based on constant dollars), were collected from two publications: U.S. Military Aircraft Cost Handbook and U.S. Military Missile Cost Handbook.[12]

The handbooks provide data for numerous weapon system

TABLE 2

SAMPLE PROJECTS

Project	Contractor	Years	Slope
F-102A	General Dynamics	53-57	.724
F-100D	North American	54-56	.934
F-101A/B/C	McDonnell Douglas	54-59	.802
F-8A/B/C	Vought	55-58	.831
A-4B	McDonnell Douglas	55-57	.834
F-104A/B/C	Lockheed	56-57	1.154
B-52G	Boeing	57-59	.869
F-105B/D	Republic	57-62	.759
F-106A/B	General Dynamics	57-59	.837
A-4C	McDonnell Douglas	57-62	.894
F-8D/E	Vought	58-63	.882
F-4A/B	McDonnell Douglas	59-66	.834
P-3A	Lockheed	60-64	.718
AIM-9C	Motorola	61-67	.961
RIM-8E	Bendix	61-66	.916
A-6A	Grumman	61-69	.829
RIM-2D	General Dynamics	61-64	.976
RIM-2E	General Dynamics	61-66	.921
RIM-24B	General Dynamics	61-66	.923
A-4E	McDonnell Douglas	61-64	.892
F-4D	McDonnell Douglas	64-66	.886
A-7A/B	Vought	65-67	.852
P-3B	Lockheed	65-67	.910
RIM-66A	General Dynamics	66-70	.763
RIM-67A	General Dynamics	66-74	.825
A-7E	Vought	67-79	1.000
A-37B	Cessna	67-73	.935
A-7D	Vought	68-75	.950
P-3C	Lockheed	68-82	.972
AIM-7F	Raytheon	68-80	.773
A-6E	Grumman	70-79	.937
F-111F	General Dynamics	70-74	1.115
F-14A	Grumman	71-82	.990
RIM-66B	General Dynamics	71-80	1.135
S-3A	Lockheed	72-76	.846
F-15A	McDonnell Douglas	73-79	.917
RIM-67B	General Dynamics	73-82	1.041
AGM-78D	General Dynamics	73-75	1.088
AH-1S	Bell	75-80	.891
A-10A	Fairchild	75-82	.963
AH-1T	Bell	76-78	1.021
F-16A	General Dynamics	78-82	.954
F/A-18A	McDonnell Douglas	79-82	.860
AIM-7M	Raytheon	80-82	.880
RIM-66E1	General Dynamics	80-82	1.089
BGM-109	General Dynamics	80-82	.943

programs but programs had to pass three filters to be included in the study. First, programs had to run at least three years in order to calculate meaningful slopes. Second, programs that were duplicates were eliminated. For example, price histories for the A-7A and A-7B were available both individually and combined as one program. The combined history was used, the individual programs were not. Third, programs where learning curves fit to the raw price data provided a poor "fit" were eliminated. Since the purpose here is to explain variations in price-reduction curves, only programs with well-defined price reduction slopes were included. An R^2 value in excess of .6 was used as a cutoff for program inclusion. The remaining group consisted of 46 programs. Program identifiers, the manufacturer, the year of program initiation and price reduction slopes for the 46 programs are provided in table 2.

Correlation Analysis

In general our objective was to determine if the explanatory factors outlined earlier explained variation in the price reduction slopes in a manner consistent with our predictions. As a first step, we correlated each variable independently with price reduction slope. Expected signs (assuming the factors are related to pricing strategy in the way we anticipated) and actual correlations are in table 3. Several findings are of interest. Seven of the twelve variables are significant at traditional significance levels and each of the seven has the predicted sign.

These initial findings suggest that programs of larger size

TABLE 3

CORRELATIONS WITH PRICE REDUCTION SLOPES

Variable	Expected Sign	Correlation
PVALUE	+	-.11
PLENGTH	+	.18
PSIZE	-	-.33*
DEFSPND	-	-.34**
DEFGRO	-	-.42**
CAPU	-	.18
CAPUGRO	-	-.42**
ECONGRO	-	-.12
INFLA	-	.18
FUNDS	+	.37**
YEAR	+	.38**
FOLLON	+	.36**

* P< .05
** p< .01

(PSIZE) may motivate skimming. Skimming also appears to be encouraged when defense spending is great relative to total federal spending (DEFSPND), when defense spending is growing (DEFGRO) and when industry capacity utilization is growing (CAPUGRO). A penetration strategy seems to occur when initial funding for a program is great (FUNDS). There has also been a general trend toward penetration pricing over the last three decades (YEAR). And as expected, price reduction is less evident for follow on programs (FOLLOW).

Multivariate Tests

While univariate correlations provide some insights, perhaps a fuller story can be told by controlling for possible inter-relationships between the explanatory variables in a multivariate model.

We used stepwise multiple regression to create a model including several variables jointly explaining the variance in slopes. Stepwise regression is a statistical procedure which adds one variable at a time to a model depending on which variable most assists in explaining the variable of interest, in this case price reduction slope. By selectively influencing the entry of variables into the model during the stepwise procedure, a researcher has some control over the model that results and gains some insight into the interrelationship between explanatory variables and their relative ability to explain the dependant variable. In short stepwise regression is a method of exploration.

We investigated various models in a heuristic and iterative fashion. We were concerned with two qualitative factors in constructing the model:

1. Parsimony: We preferred a model with few variables.
2. Lack of interrelationship between explanatory variables: High correlation between pairs of variables or high "collinearity" among several variables in a model causes coefficients to be less meaningful and the model to be less useful for prediction.

We considered three statistical items to determine when we had arrived at a "good" model:

1. The overall significance of the model (F value).
2. The significance of individual ratios in the model (t statistics for ratio coefficients).
3. The explanatory power of the model (adjusted R-squared values).

Table 4 provides detail on a representative model. Looking at the table, several items are of note: The model is highly significant and has a reasonably high R^2 value. It explains about half of the variation among contractors in price reduction slopes. Each of the five variables included in the model is significant with the predicted coefficient sign.

Interpretation of the Model

In general the model demonstrates that pricing strategy is significantly associated with various factors reflecting features of the program or the contracting environment and suggests that

TABLE 4

A MULTIVARIATE MODEL

Variable	Coefficient	t-Value	significanc
Intercept	.337		
FOLLON	.053	2.25	.003
FUNDS	.356	3.93	.001
PLENGTH	.008	1.95	.058
DEFGRO	-.188	-2.05	.047
YEAR	.006	4.03	.001

F Value: 8.19 R-Square: .51
Significance level: .0001 Adjusted R-Square: .44

TABLE 5

CORRELATIONS BETWEEN EXPLANATORY VARIABLES

PLENGTH	PSIZE	DEFSPND	YEAR	INFLA	DEFGRO	CAPU	CAPUGRO	ECONGRO	FUNDS	FOLLON
.27	.34	.15	-.07	-.10	.12	-.11	.03	-.14	-.20	-.36
H	-.20	-.17	.12	-.15	.18	.12	-.19	.11	-.48	.10
		.57	-.12	-.55	.23	.13	.41	-.20	-.01	-.16
D			-.93	-.54	-.08	-.01	.03	-.21	.19	-.09
				.68	.25	.07	.00	.19	-.13	.12
					.32	.20	.25	-.09	-.12	.08
						.66	.65	.42	-.05	.14
							.47	.42	-.11	.23
D								.40	.07	-.03
D									.08	-.05
										.12

attention to these factors may be useful for detecting contractor pricing strategy. A relatively small collection of variables appears to explain a fair amount of variation in price reduction slopes.

The individual explanatory variables in the model are also of interest but taking a look at some interrelationships between the explanatory variables is necessary for a more complete interpretation. Table 5 provides pairwise correlations between the explanatory variables. In general the correlations are relatively low, with the exception of correlations within two subsets of the variables (enclosed in the triangles). DEFSPND, YEAR, INFLA and PSIZE are interrelated. The high positive association between INFLA and YEAR is perhaps not surprising; it is well known that inflation was higher in the 1970's than in earlier decades. In retrospect, the high negative association between DEFSPND and YEAR is also not surprising; the growing emphasis on social programs, starting in the 1960's, has reduced the proportion of government spending devoted to defense programs. (In fact the very high correlation between DEFSPND and YEAR suggests that these two measures are almost substitutes for each other.)

Similarly, DEFGRO, CAPU, CAPUGRO and ECONGRO are positively inter-related. Again this is not surprising. General economic growth (ECONGRO) should be reflected in growth within the aerospace industry (CAPUGRO). General economic growth should also make defense spending growth (DEFGRO) more acceptable, which

should be reflected in aerospace industry growth.

When sets of individual explanatory variables are highly associated with each other they tend to collectively capture some common underlying dimension.[13] Inclusion of one variable in a regression model reduces the chance that another from the same set will provide additional power to explain the dependant variable. With this as background, a better interpretation of the variables in the model is possible. The model shows that five factors explain price reduction slopes.

1. Follow-on Programs: Price reduction slopes tend to be flatter when the program is a new model of a previously produced weapon system. This was expected since the most substantial learning, and cost reduction, should occur during the first production model.

2. Program Funding: Variable FUNDS was one of the most consistently important and highly significant explanations of pricing strategy in all regression models constructed. When initial obligational authority for a program was high relative to the total value of a program, contractors tended to use the penetration strategy. This indicates that the apparent commitment of the government to a program, as reflected in funds initially allocated, impacts contractor pricing. High initial commitment may reduce contractor fear that the program will be terminated or curtailed before sufficient returns can be realized and, by reducing this risk, permit the contractor to reduce initial prices during contract negotiation.

3. Program Length: The penetration strategy was also associated with programs that extended for longer periods of time. Extended programs may benefit contractors by allowing them to lock in revenues for future periods and reduce the costs and uncertainty associated with the level of operations in future periods. Such benefits appear to be reflected in a greater willingness to reduce initial prices.

4. Industry Condition and Outlook: Variable DEFGRO appears in the model presented in table 4 but, as discussed above, several other variables tend to capture the same underlying dimension. Other models were constructed including CAPU or CAPUGRO in place of DEFGRO, with little decrease in explanatory power. Thus it is probably not growth in defense spending per se that affects pricing strategy. Rather growth in defense spending is associated with higher utilization of industry capacity and expectations of continued industry health. And when capacity is adequately being utilized incentives to compete for new defense projects are reduced. Consequently skimming pricing strategies are pursued.

5. Trend: Variable YEAR appears in the model presented in table 4 but YEAR was correlated with other variables, particularly DEFSPND. (DEFSPND could replace YEAR in the model with little effect on explanatory power.) What is clear is that there has been a trend over the last three decades towards increasing use of the penetration strategy. This could be due to the increasing emphasis over time on non-defense spending causing

contractors to reduce initial prices in order to buy into the budget. As indicated earlier, other explanations are also possible. Increasing scrutiny of defense acquisitions may motivate contractors to reduce initial price demands, while the increasing interdependence of DoD and defense contractors may permit contractors to renegotiate later prices, insuring satisfactory profits. These effects would result in the apparent trend toward penetration strategies.

Final Comment

Our objective has been to provide evidence concerning the effect of various factors on contractor pricing strategy. Our purpose in presenting the model was to document and describe the nature of those effects. Our findings suggests that program features and features of the acquisitions environment impact the pricing strategy used by defense contractors. Taken as a whole the analysis suggests three broad conclusions:

1. There has been a general trend toward buy-in or penetration pricing strategies during the last three decades. This is consistent with the trend toward greater non-defense federal spending motivating contractors to buy into the budget with reduced initial prices.

2. Contractors tend to adopt penetration strategies when initial funding for a program is high and when the expected duration of a program is long. Both of these factors may provide contractors with some assurance that a program will not be terminated before sufficient returns can be earned and

consequently permit contractors to reduce initial price.

3. Contractors tend to adopt skimming strategies when defense spending and industry capacity utilization are increasing or when capacity utilization is high. This is consistent with strong demand for the industry's output lessening contractor incentive to reduce initial price.

It should be noted that this study has addressed defense programs over a three decade period. The acquisitions environment has changed significantly during that period. Today the emphasis is on increased competition in defense procurement. This has been reflected in policies toward increased financing of contractor facilities by the government, with the objective of opening the door to competition and increasing the possibility of second sourcing. We now have "competition advocates." And performance measurement of contracting officers incorporate measures designed to reflect the degree to which competition in procurement is achieved. The result of these and other changes in the acquisitions environment suggest that contractors may be increasingly facing circumstances in which penetration-type strategies may be necessary to secure contracts. (This is consistent with the general trend toward penetration noted in the sample.) What has changed by the increased competition demanded by the government, however, is the range over which different pricing strategies may be effectively pursued, not the concept of pricing strategy per se. It is likely that the incentives outlined in this article still influence contractor actions.

We hope that contracting officers, program managers or others involved in acquisition activities may gain some insight into the pricing practices of contractors from our analysis.

NOTES

1. For a discussion of pricing strategies see "The Pricing Decision: Part I - The Cornerstone of the Marketing Plan," Small Business Report, Vol. 10, No. 5, May 1985, pp. 71-77; Dean, J., "Pricing Pioneering Products", Journal of Industrial Economics, (July 1969), pp. 180-187; and Wind, Y. Product Policy: Concepts, Methods and Strategy, (Addison-Wesley, 1982).

2. For further elaboration of features of the skimming strategy see Dean, op. cit. and Caferelli, E., Developing New Products and Repositioning Mature Brands, (Wiley 1980).

3. Direct quotation from Caferelli, op. cit., p. 176.

4. Direct quotation from "The Pricing Decision", op. cit., p.77.

5. See Wasson, C., Dynamic Competitive Strategy & Product Life Cycles, (Challenge Books, 1974).

6. See Greer, W., and S. Liao, "Cost Analysis for Competitive Major Weapon System Procurement: Further Refinement and Extension, "Naval Postgraduate School Technical Report, NPS 54-84-023, Monterey, CA., Sept. 1984.

7. Greer, W. "Early Detection of a Seller's Pricing Strategy," Program Manager, Nov-Dec. 1985, pp. 6-12.

8. In a related study, K. McGrath and O. Moses investigated the links between pricing strategy and contractor's financial condition. Using a sample of defense aerospace contractors, similar to the sample in this paper, they found that firms with lower financial risk and lower utilization of assets tended to penetrate. See "Financial Condition and Contractor Pricing Strategy", Program Manager (September-October 1987), pp. 11-19.

9. Note that these first three variables, (program value, program length, program size), use measures of the actual value of a program and the actual length of a program in their computation. Actual value and length would not be known prior to completion of the program. In principle, measures of the "expected" value or length of a program should be used to reflect the pricing strategy incentives hypothesized to exist before production commences. Use of the ex post actual measures assumes that they are reasonable surrogates for ex ante expectations. Alternative measures

for program value and program size were determined using the initial obligational authority for the programs rather than total costs over the program life. Findings were similar using these alternatives. Constant dollar measures were used for all alternatives.

10. Defense spending was measured one year prior to the start of production on a program. Growth in defense spending was measured over the period from two years to one year prior. This assumes that measures taken at that point in time are representative of the environment in existence when contractor pricing strategy was formulated. Other variables designed to reflect industry and economic conditions were measured at analogous points in time prior to the start of production.

11. Contractors may have separate divisions for commercial and DoD work, each being operated, in effect, as separate businesses, with corporate headquarters acting in the role of a bank providing funds to finance projects. Ideally we would like a measure of the capacity utilization of the DoD division of firms to more precisely capture the incentives that may be operating. Such measures however were not readily available. Industry measures provide a rough surrogate. In any event, work by Greer and Liao, op. cit., indicates that industry measures of capacity utilization prove to be better predictors of contractor pricing behavior than to firm specific capacity utilization measures.

12. DePuy, S., et al., U.S. Military Aircraft Cost Handbook, TR-8203-1, (Management Consulting & Research, Inc., 1983) and Crawford, D., et al., U.S. Military Missile Cost Handbook, TR-8203-3, (Management Consulting and Research, Inc., 1984).

13. A formal factor analysis of the explanatory variables was conducted. PSIZE, DEFSPND, YEAR and INFLA formed a distinct factor with YEAR having the highest factor loading. Similarly DEFGRO, CAPU, CAPUGRO AND ECONGRO form a distinct factor, with CAPUGRO having the highest factor loading. All other variables represented distinct individual factors. Regression models using factor scores rather than individual variables were substantially similar to the model presented in table 4.

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